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(54) Electrical connector

(57) An underwater electrical connector comprises male and female parts which are brought together to make an electrical connection. The female part 2 includes first, second and third closed chambers 28, 29, 30 containing electrically insulating media, the second chamber 29 being located within the first 28, and the third chamber 30 being located within the second 29. An electrically insulating shuttle piston 46 extends through a contact socket 23 disposed in the third chamber 30 and through respective aligned openings 40, 41, 42 of the three chambers. The shuttle piston 46 is arranged to be urged back by a contact pin of the male part of the connector during insertion thereof such that the contact pin is received and directly engaged by the contact socket 23 in the third chamber 30 to effect the electrical connection.

Fig. 2.

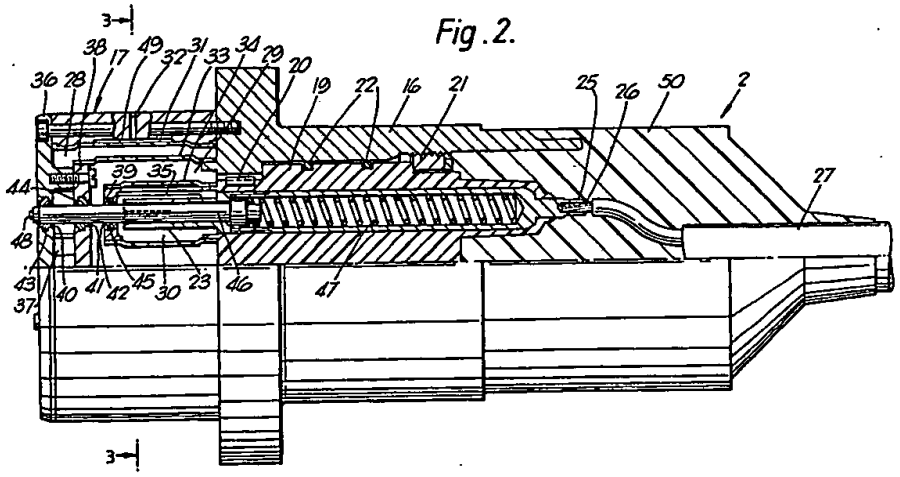
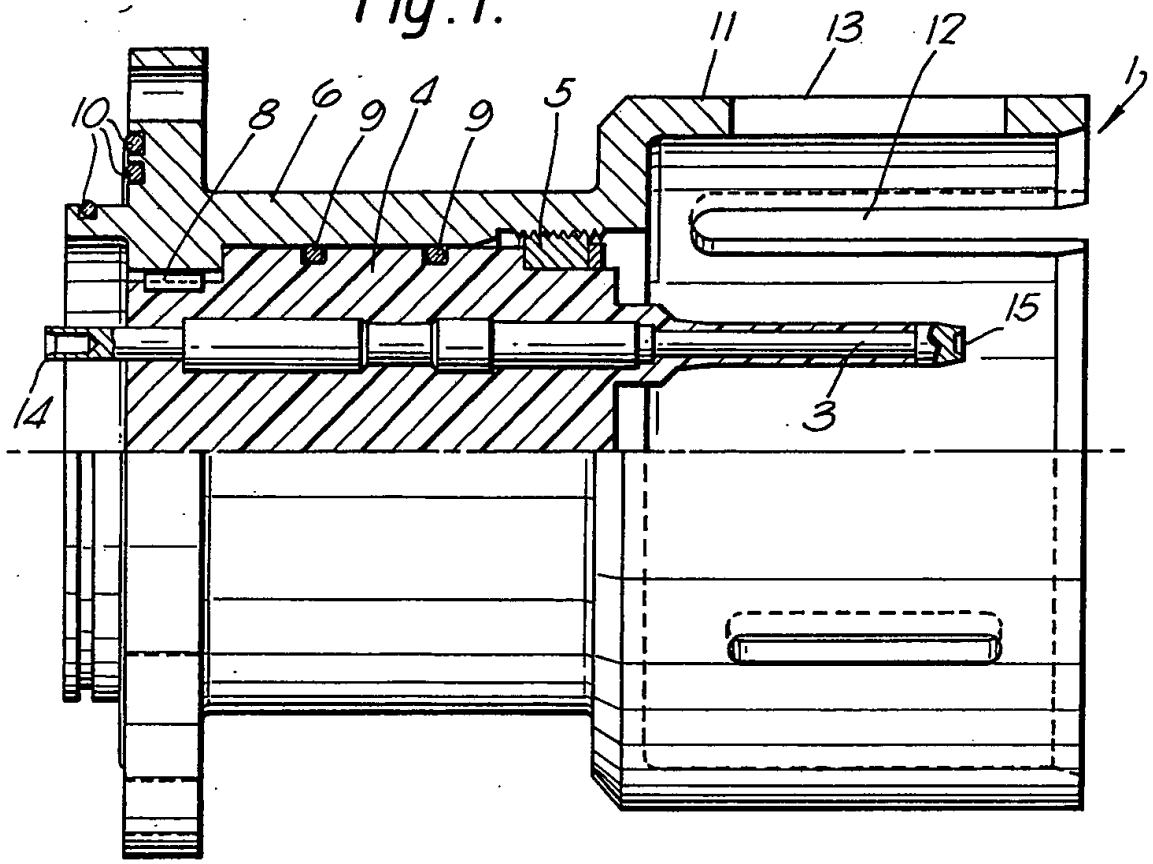


Fig. 1.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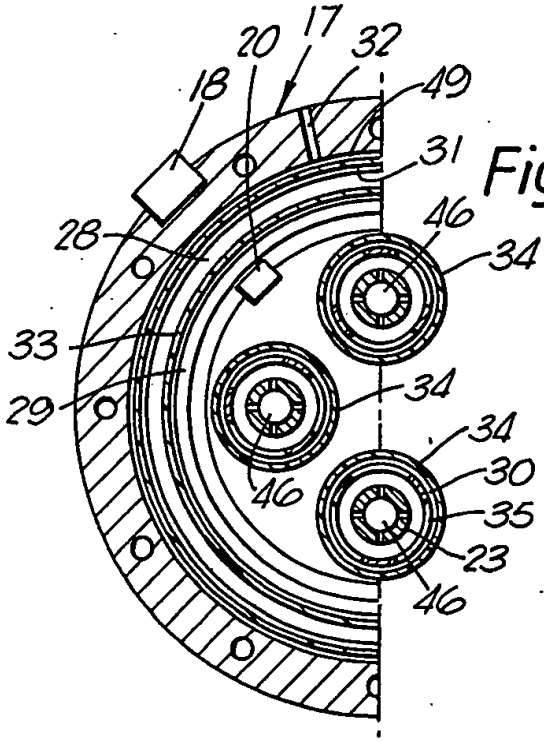
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Fig. 3.

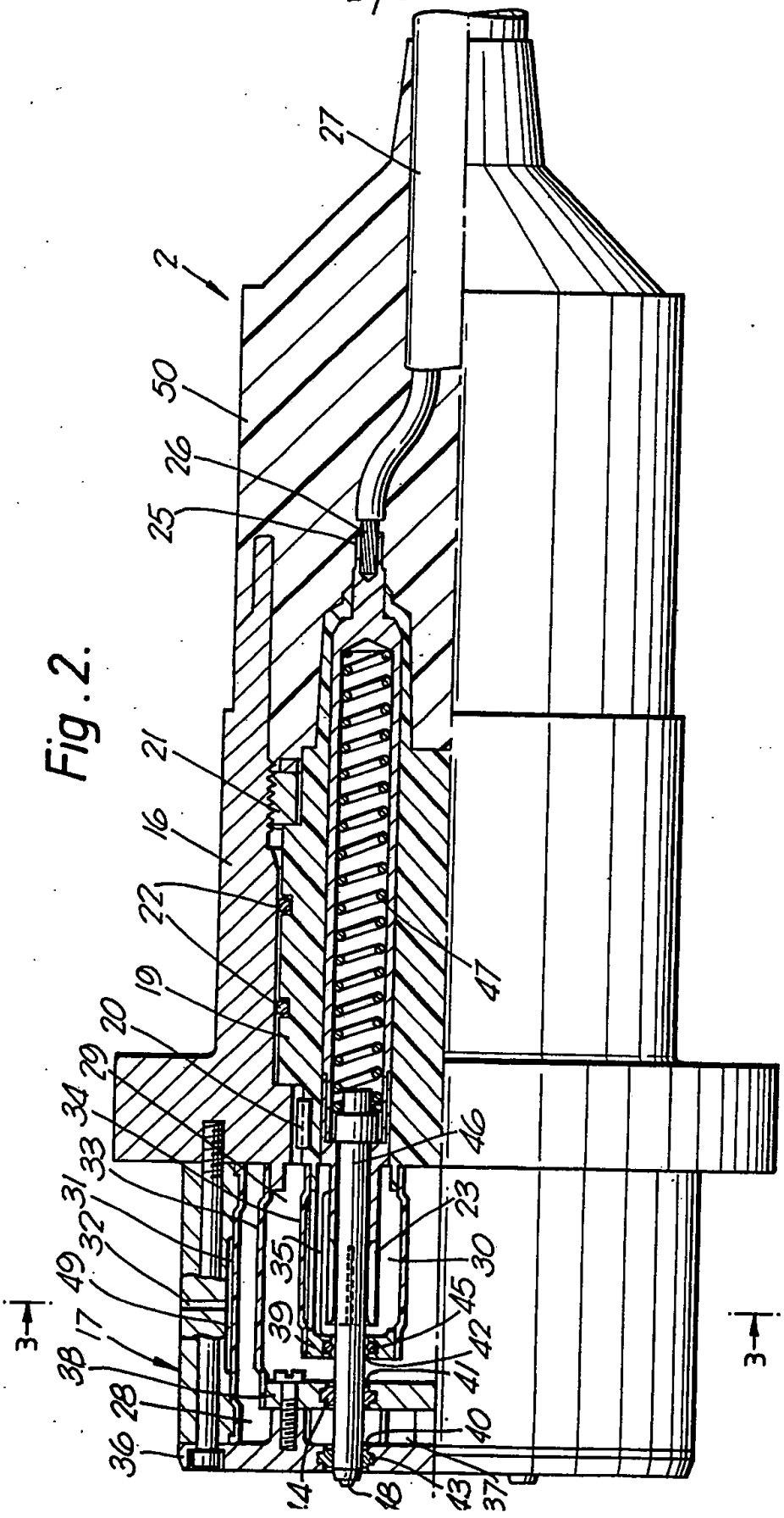
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Fig. 2.

Fig. 4.

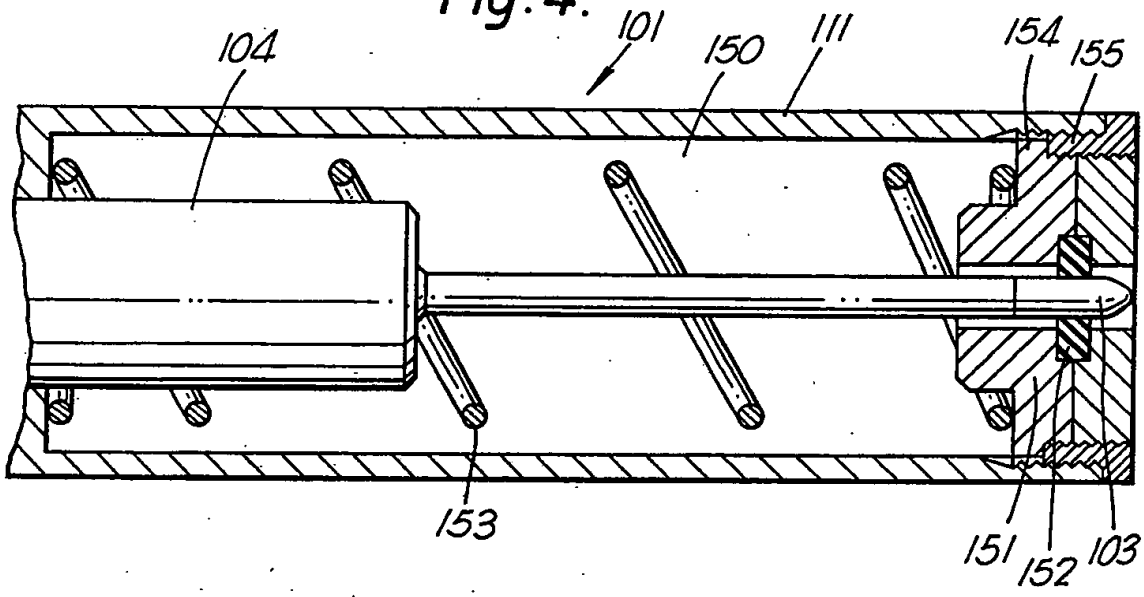
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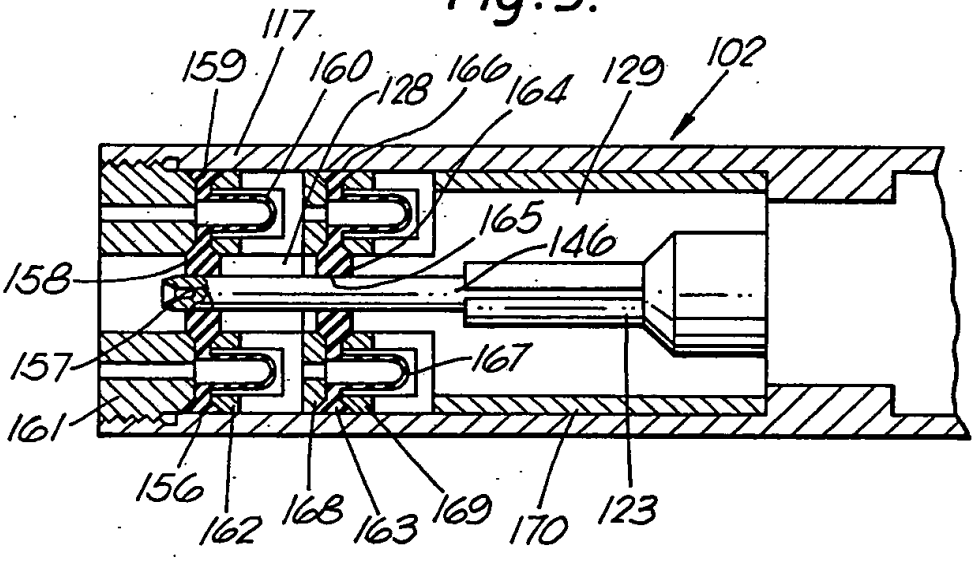
Fig. 5.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SPECIFICATION

Electrical connector

The invention relates to an underwater electrical connector comprising male and female parts which are brought together to make an electrical connection.

Underwater electrical connectors are known in which the female part has an electrical contact disposed within a closed chamber filled with an insulating grease or oil to provide a protected area around the contact where a connection is to be made. It has been proposed in U.S. Patent No. 3,729,699 to provide the oil filled chamber with an opening which is sealed by a spring biased slidable shuttle piston arranged to be pushed back by engagement of a projecting male contact pin with the piston. By thus providing a shuttle piston, very little, if any, distortion of the opening is required, and the opening can be quite large to permit large pin diameters for heavy current and/or a multi-service arrangement such as a coaxial connection.

The opening of the chamber is closed either by the shuttle piston in the unmated condition of the connector or by the male contact pin when the male and female parts of the connector are brought together. A seal for the opening is provided in the form of a pair of spaced O-rings for engaging the shuttle piston or the contact pin, depending on which of these extends through the opening. With this arrangement there is a risk of deterioration of the seal which may result in water or contaminants entering the chamber where the electrical connection is made.

According to the invention there is provided an underwater electrical connector comprising male and female parts, the male part having a contact pin and the female part having contact means within or inwardly of a chamber containing electrically insulating media, the chamber being provided with an opening normally closed in sealing manner by a resiliently biased shuttle piston which extends through the opening and is arranged to be engaged and urged back by the contact pin during insertion thereof to cause an electrical connection to be made with the contact means of the female part, wherein the female part has first and second closed chambers containing electrically insulating media and each provided with a respective opening, the openings being aligned and normally sealed by the shuttle piston extending therethrough, the second chamber being located within or inwardly of the first chamber and the contact means being located within or inwardly of the second chamber.

With such an arrangement, if for example the quality of the seal of the first chamber opening deteriorates and allows entry of water or contaminants, then the provision of a second closed chamber located within or inwardly of the first ensures that the region where the contact means is located is not contaminated. Thus a reliable, electrically insulated electrical connection can be ensured. The electrical insulating media in the chambers will generally be a dielectric fluid such as oil, grease or the like.

The electrical intergrity of the two chamber connector can be further improved by providing a third chamber containing electrical insulating media and located within or inwardly of the second chamber, the third chamber having an opening aligned with the other openings and normally sealed by the shuttle piston extending therethrough, the contact means being located within the third chamber. In the event of breakdown of the sealing of the openings to the first and second chambers, then the third chamber provides further protection for the region where the electrical connection is made.

The shuttle piston might have a conducting portion which is engaged by the contact pin and which engages the contact means within or inwardly of the second chamber when the piston is pushed back, thereby completing the electrical connection. However, the shuttle piston is preferably formed of electrically insulating material and extends through a female contact socket located within or inwardly of the second chamber, whereby the electrical connection is made by the contact pin pushing back the shuttle piston to be received and directly engaged by the contact socket. This arrangement, whole providing the advantages of a shuttle piston referred to above, avoids the need for a double electrical connection i.e. that between the contact pin and the piston and that between the piston and the female contact means.

Since the contact socket is provided within a chamber containing electrically insulating media, it can be "live" prior to and during mating of the male and female parts of the connector.

It is desirable that the connector can withstand high pressures so that it can be used underwater at depth. Thus, the connector may include means for effecting balancing of the media pressure in the respective chambers relative to the pressure outside the connector. This can be done by making the chambers containing insulating media variable in volume so as to adapt to pressure changes and thus inhibit the entry of water through the respective openings. This may be achieved by means of a piston or the like, but preferably each chamber has a wall formed at least partly of a flexible membrane arranged to permit variation of the respective chamber volume. The flexible membrane may be formed as part of the same member which normally seals the chamber opening, or it may be provided separately at a convenient location.

The normally sealed openings of the first and second chambers are generally formed in respective front walls thereof, and in one preferred embodiment each chamber has a flexible membrane in a side wall thereof, the membrane of the second chamber being laterally inwardly spaced from the side wall of the first chamber. Thus, in this embodiment the second chamber is defined within the first. In this arrangement the first chamber membrane is arranged to be exposed to the pressure of ambient water while the second chamber membrane is exposed to the pressure of media in the first chamber. If a third chamber is provided this can also have a flexible membrane in a side wall thereof laterally inwardly spaced from the second chamber side wall.

In another embodiment in which the normally sealed openings are formed in respective front walls of the chambers, the chambers share a common outer

side wall, the second chamber being located inwardly of the first. A flexible membrane for each chamber might then be provided in the outer wall, each membrane being exposed to the presure of ambient water, but preferably the flexible membranes are provided in the respective front walls.

The male part of the connector may include a slidably mounted wiper seal engaging the contact pin and resiliently biased towards the contact end thereof, the seal being arranged to be moved back over the pin during mating of the male and female parts. The wiper seal may, for example, be mounted by a slidable piston which defines the forward end of a chamber for the contact pin.

The male part of the connector may be provided with a single contact pin or it may have a plurality of pins with the female part having the same number of contacts means. Preferably four or more contact pins are provided, and they might for example be uniformly spaced around the central longitudinal axis of the connector. If a third chamber is provided it might enclose all the female contact means collectively, but preferably each contact means corresponding to a respective contact pin is separately enclosed by an individual third chamber.

Certain preferred embodiment of the invention will now be described by way of example and with reference to the accompanying drawings in which:—

Fig. 1 is a partly sectioned side elevation of the male part of an electrical connector;

Fig. 2 is a partly sectioned side elevation of the female part of the connector;

Fig. 3 is a part section on the lines 3-3 of Figure 2;

Fig. 4 is a section through the male part of a second embodiment of electrical connector; and

Fig. 5 is a section through the female part of the connector of Figure 4.

The electrical connector basically comprises a male part 1 to be connected underwater with a female part 2. Referring firstly to Figure 1, the male part 1 includes four projecting contact pins 3 bonded to an insert 4 held by a retaining ring 5 in a connector socket 6. The connector socket may be moulded or it may be fabricated e.g. by machining to the correct size and shape. The insert 4, which may be formed of epoxy resin or other suitable insulating material, is correctly located by means of a key and key-way 8 at its rear end and is sealed to the connector socket 6 by a pair of insert O-rings 9. The connector socket is provided with three bulkhead seals 10 to ensure sealed engagement with a bulkhead. At its forward end the connector socket has an outer shroud 11 surrounding the four contact pins and having a key-way 12 for accurate mating with the nose of the female connector part 2. Slots 13 are provided for displacement of water as the outer shroud 11 receives the nose of the female part. The contact pins are each provided at the rear end with a solder cup 14 for connection with a respective conductor and at the front end with a cone-shaped recess 15 for positive engagement with a corresponding projection of the female part during mating.

Referring to Figures 2 and 3, the female part 2 of the connector includes a connector plug 16 to which is secured the nose 17 having a key 18 for engagement Other location/guidance arrangements could be used. Similarly to the arrangement of the connector socket 6, the connector plug 16 is provided with an e.g. epoxy resin insert 19 located by a key and key-way 20 and held by a retaining ring 21, the insert being sealed to the connector plug by a pair of O-rings 22. Four tubular contact sockets 23 are bonded within the insert 19 and are each provided at the rear end with a solder cup 25 for connection with a respective conductor 26 of a cable 27. Alternatively, a crimped or other type of connection might be used. The connection is encased in a polyurethane moulding 50 bonded to the connector plug 16, the insert 19 and the cable 27. The female part of the connector could also be provided in a form which is more readily installable onsite.

At their forward ends the tubular contact sockets 23 project into the connector plug nose 17. Within the nose 17 are defined a first outer chamber 28, a second chamber 29, and four individual third or inner chambers 30 each enclosing the projecting end of a respective contact socket 23. All the chambers are filled with insulating media such as a dielectric fluid e.g. oil, grease or the like. The first chamber 28 has an annular outer wall comprising a flexible membrane 31 the outer surface of which is vented to the outside by a pressure compensating vent hole 32. This ensures that when the connector is submerged and is subject to increasing pressures, the membrane deflects inwardly to decrease the volume of the chamber and so balance the pressure. In this way any tendency for water from the outside to enter the chamber is reduced. An annular space 49 around the outside of the membrane 31 allows dielectric fluid displacement when the contact pins enter the chambers during mating. The second chamber 29 is enclosed within the outer chamber 28 and is similarly provided with an annular flexible membrane 33. The individual inner chambers 30 also each have an annular flexible membrane 34, each carried by lantern type supports 35 projecting from the insert 19.

The first or outer chamber 28 is closed by a front plate 36 which has rearwardly projecting lugs 37 supporting a front plate 38 of the second chamber. The front plate 39 of each inner chamber 30 is supported by the lantern supports 35. The front plates 36, 38 and 39 of the respective chambers are respectively provided with openings 40, 41 and 42, each having an annular seal 43, 44 and 45. Referring to the arrangement associated with just one of the four inner chambers 30, a slidable shuttle piston 46 extends through the three aligned openings 40, 41 and 42 so as to close the chambers. In fact, the annular seal 45 of the inner chamber is an O-ring which has a slight clearance from the shuttle pin to reduce drag thereon, although the contact pin 3 is of larger diameter so that the seal 45 forms a close fit on the pin during mating. The shuttle pin is formed of an insulating material and is forwardly biased by a spring 47 retained within the contact socket 23. The front of the shuttle piston is formed as a cone-shaped projection 48 for positive engagement with the correspondingly shaped recess 15 of the male connector part.

To make the connection between the male and female parts of the connector the plug nose 17 is

by the mating key 18 and key-way 12. Each of the four contact pins 3 engages a corresponding shuttle piston 46 and pushes it back against the force of the spring 47. The pin passes successively through the three aligned openings 40, 41 and 42 to be received in the contact socket 23 and thereby to complete the electrical connection.

Figures 4 and 5 respectively show male and female parts 101 and 102 of a second electrical connector. Referring firstly to Figure 4 the male part 101 includes a single contact pin 103 projecting from an insert 104 and surrounded by an outer shroud 111 which defines a contact pin chamber 150. The forward end of the chamber 150 is closed by a piston 151 split into two parts which receive therebetween a wiper seal 152 engaging the outside of the contact pin. The piston is urged by a spring 153 to a forward position in which a radial projection 154 of the piston engages an abutment ring 155 secured on the end of the shroud 111. The piston is located in this forward position when the connector is in the unmated condition and the major length of the contact pin is then protected. When the male part 101 is mated with the female part 102 the piston 151 is pushed rearwardly and carries the wiper seal 152 which slides axially along the surface of the contact pin. On decoupling the connector, the spring 153 ensures that the piston and wiper seal return to the forward position, so that the contact pin chamber 150 is protected at all times from the entry of debris.

Referring to Figure 5, the female connector part 102 includes a plug nose 117 in which is mounted a tubular contact socket 123 having a slidable shuttle piston 146 extending axially therethrough, as in the embodiment of Figures 1 to 3. Within the plug nose 117 are defined a first, outer chamber 128 and a second, inner chamber 129 which encloses the contact socket 123. The forward wall of the outer chamber comprises a one-piece closure member 156 having a central axial opening 157 through which the shuttle piston 146 extends. The closure member 156 is formed of a flexible material and has an inner ring seal 158 defining the opening 157 and an outer ring seal 159 in sealed engagement with the inside surface of the plug nose 117. The ring seals 158 and 159 are connected together by an integral, relatively thin, flexible membrane 160 of the closure member which is arranged to project rearwardly into the outer chamber 128 and to flex so as to allow volume changes thereof, similarly to membrane 31 of the first embodiment. The closure member 156 is retained in position on its forward side by a nut 161 having axial passages therethrough to communicate the outside of membrane 160 with ambient water pressure, and on its rear side by a cage support 162 which also serves to support the membrane.

A second closure member 163 separates the outer and inner chambers 128 and 129. The member 163 has an inner ring seal 164 defining an opening 165 for the shuttle piston, an outer ring seal 166 in sealed engagement with the inside surface of the plug nose 117, and an integral flexible membrane 167 connecting the ring seals together. The closure member is retained on its forward side by a washer 168 having axial holes therethrough to communicate the membrane 167 with the pressure in the outer chamber 128, and on its rear side by a cage support 169 which abuts against the forward end of a sleeve 170 disposed inside the plug nose 117.

To make the connection between the male and female parts 101 and 102 of the connector the plug nose 117 is inserted onto the outer shroud 111. The piston 151 of the male part is pushed back by the nose 117 and the contact pin 103 pushes back the shuttle piston 146 to pass successively through the opening 157 to the outer chamber and the opening 165 to the inner chamber. The contact pin is received in the contact socket 123 to complete the electrical connection within the inner chamber.

Although the embodiment of Figures 4 and 5 has only one pin and socket, a plurality of such of such pins and sockets could be provided in a connector.

It is to be noted that in both embodiments the various chambers containing electrically insulating media are separate and sealed from each other, the only communication between adjacent chambers being provided by the openings through which either the shuttle piston passes in the unmated condition of the connector or the contact pin passes when the male and female parts of the connector are brought together.

Modifications to the broad aspects and the specific embodiment of the invention may be apparent to a person skilled in the art and it is intended that this disclosure should extend to any such modifications.

CLAIMS

1. An underwater electrical connector comprising male and female parts, the male part having a contact pin and the female part having contact means within or inwardly of a chamber containing electrically insulating media, the chamber being provided with an opening normally closed in sealing manner by a resiliently biased shuttle piston which extends through the opening and is arranged to be engaged and urged back by the contact pin during insertion thereof to cause an electrical connection to be made with the contact means of the female part, wherein the female part has first and second closed chambers containing electrically insulating media and each provided with a respective opening, the openings being aligned and normally sealed by the shuttle piston extending therethrough, the second chamber being located within or inwardly of the first chamber and the contact means being located within or inwardly of the second chamber.

2. A connector as claimed in claim 1, wherein the shuttle piston is formed of electrically insulating material and extends through a female contact socket located within or inwardly of the second chamber, whereby the electrical connection is made by the contact pin pushing back the shuttle piston to be received and directly engaged by the contact socket.

3. A connector as claimed in claim 1 or 2, including means for effecting balancing of the media pressure in the respective chambers relative to the pressure outside the connector.

4. A connector as claimed in claim 3, wherein each chamber has a wall formed at least partly of a flexible membrane arranged to permit variation of the respective chamber volume.

5. A connector as claimed in claim 4, wherein the normally sealed openings of the chambers are formed in respective front walls thereof, the flexible membrane of each chamber being provided in a side wall thereof, and the membrane of the second chamber being laterally inwardly spaced from the side wall of the first chamber.

6. A connector as claimed in claim 4, wherein the normally sealed openings of the chambers are formed in respective front walls thereof and the chambers share a common outer wall, the flexible membrane of each chamber being provided in its respective front wall.

7. A connector as claimed in any preceding claim, including a third chamber containing electrical insulating media and located within or inwardly of the second chamber, the third chamber having an opening aligned with the other openings and normally sealed by the shuttle piston extending therethrough, the contact means being located within the third chamber.

8. A connector as claimed in claim 7, wherein the male part has a plurality of contact pins and the female part has the same number of contact means, each contact means being separately enclosed by an individual third chamber.

9. A connector as claimed in any preceding claim, wherein the male connector part includes a slidably mounted wiper seal engaging the or each contact pin and resiliently biased towards the contact end thereof, the seal being arranged to be moved back over the pin during mating of the male and female parts.

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(51) INT CL[6]
H01R 13/631

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H2E ECD E237 E239

(56) Documents Cited
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(58) Field of Search
UK CL (Edition O) H2E ECD
INT CL[6] H01R , H02G
Online: WPI

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(54) Abstract Title
Connector assembly allowing lateral movement

(57) A connector assembly 1 comprises first and second connector parts 5,6, the first connector part being mounted by a carriage 7 being reciprocatable between a forward position for connecting the connector parts and a retracted position for disconnecting the connector parts, wherein the mounting of the first connector parts by the carriage is such as to permit pivoting of the first connector part in response to a force in any lateral direction on the first connector part and acting at a location forward of the mounting.

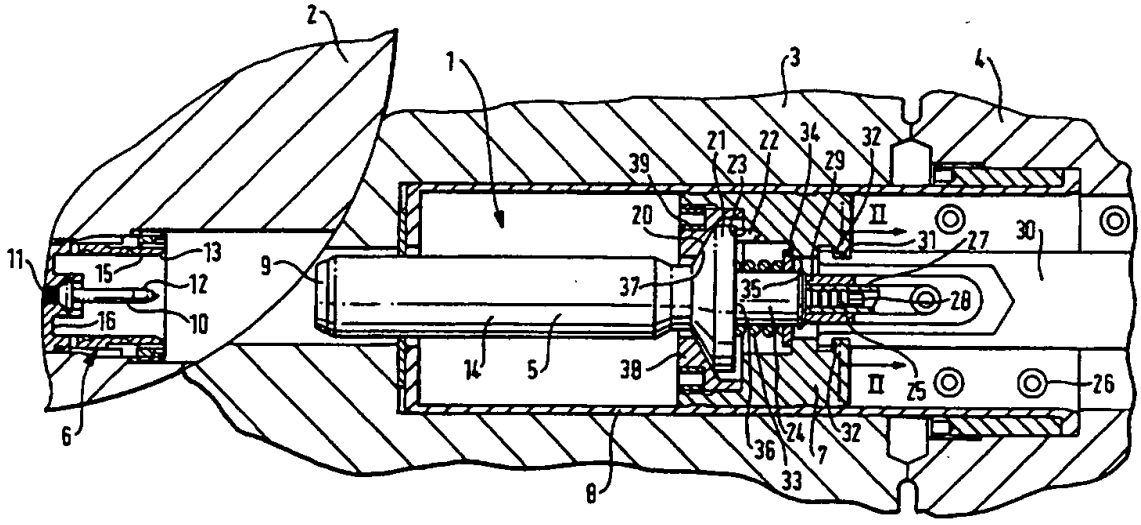

FIG. 1

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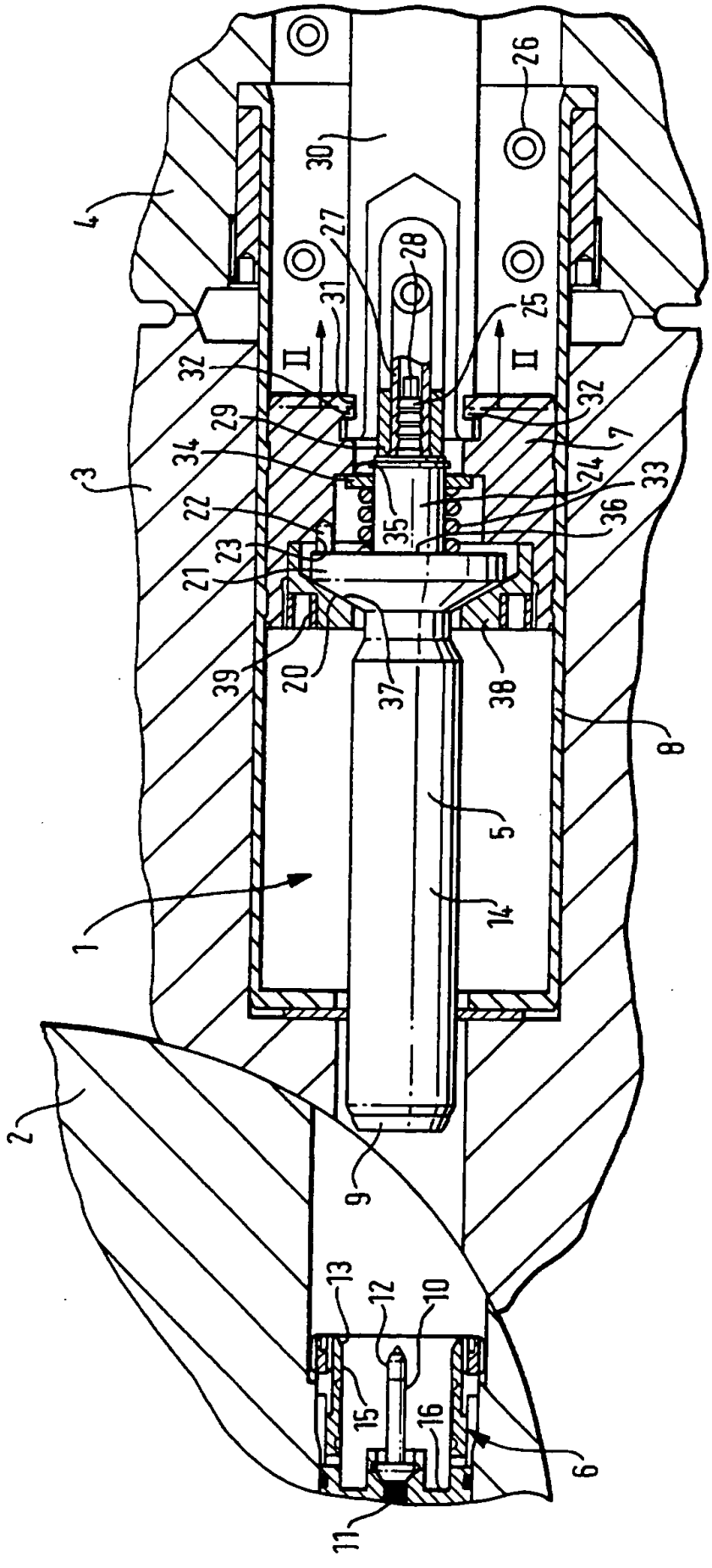
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FIG. 1

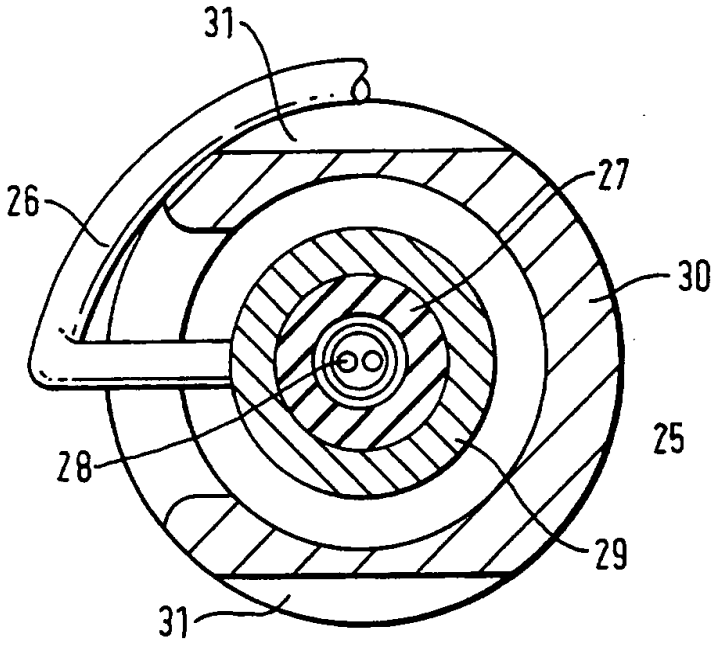


FIG. 2

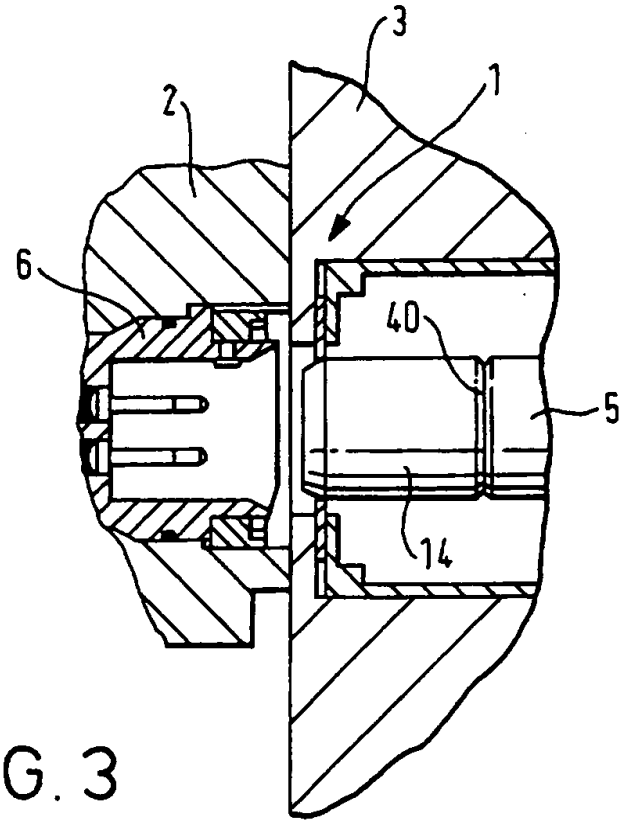


FIG. 3

FIG. 4

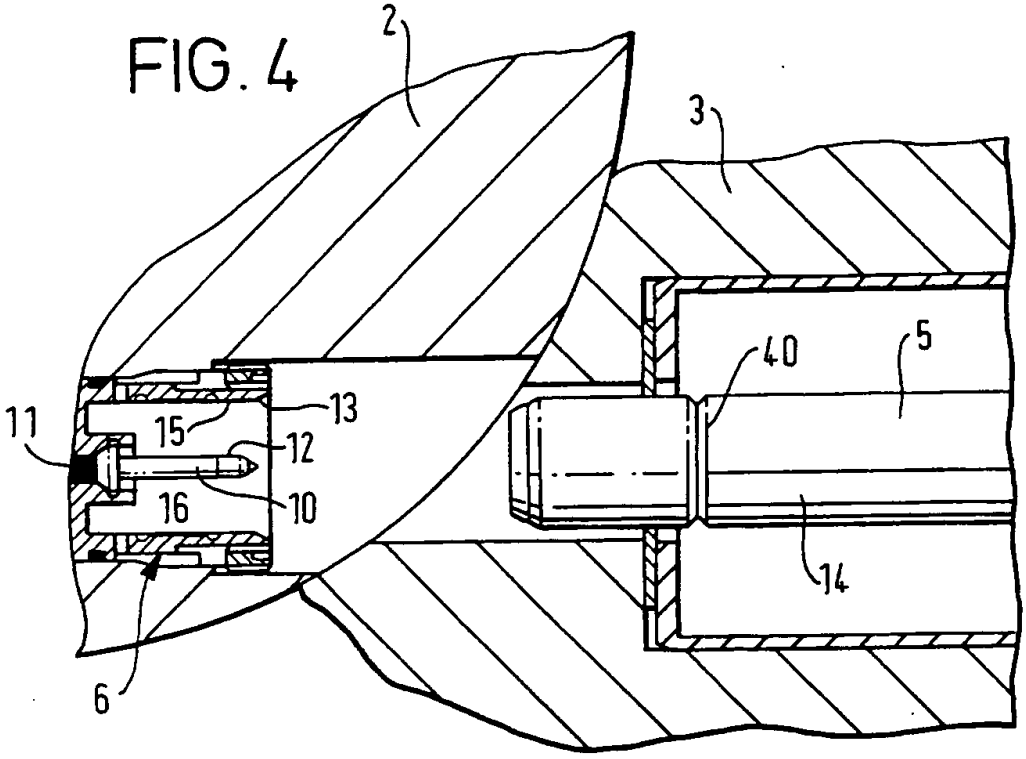
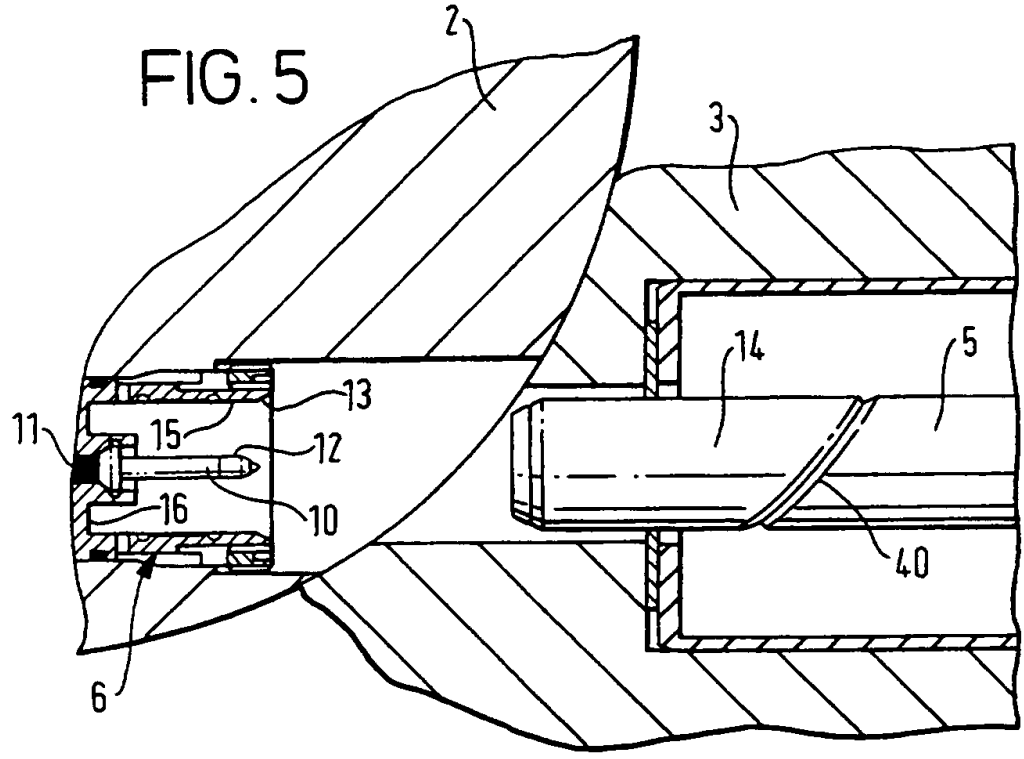


FIG. 5



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Connector Assembly

The invention relates to a connector assembly and to a wellhead assembly provided with such a connector assembly.

It is known from US-A-5 558 532 to provide an underwater wellhead assembly comprising a vertically oriented tubing hanger disposed in a spool body, and a connector assembly comprising a first connector part in the form of a plug body and a second connector part in the form of a receptacle for the plug body. The receptacle is arranged in the tubing hanger with its axis horizontal and the plug body is mounted by a carriage horizontally reciprocatable between a forward position in which the connector parts are connected and a retracted position in which the connector parts are disconnected. In the retracted position the plug body is fully withdrawn from the tubing hanger so that it is then possible to remove the tubing hanger, together with the receptacle, vertically from the spool body and to take it to surface for repair or modification. Each time the tubing hanger is returned to the spool body it has to be accurately located so that the connector parts are in alignment with each other. However, because of manufacturing tolerances exact alignment is not always achieved, and there may be a lateral offset between the longitudinal axes of the connectors (lateral misalignment), or an angular misalignment between the axes, or a combination of the two. If there is misalignment, there may be a problem in that the plug body cannot properly engage the receptacle during the forward movement of the carriage.

To deal with this problem, we have previously proposed a mounting arrangement for the plug body on the carriage which allows lateral movement of the plug body

relative to the carriage, and limited pivotal movement about a vertical axis only. This mounting arrangement consists of a pair of radially outwardly projecting circumferential flanges on the plug body, the flanges being longitudinally spaced from each other, and a split ring on the carriage projecting radially inwardly into the space between the flanges. An O-ring is disposed around the plug body radially inwardly of the split ring. The plug body is able to move laterally relative to the carriage, if necessary to correct lateral misalignment as it engages in the receptacle, by deforming the O-ring. In addition, because the split ring projects into the space between the plug body flanges at the top and the bottom of the plug body, but not at the sides, a small amount of pivotal movement about a vertical axis is possible to correct angular misalignment.

Such a mounting arrangement works well. In some circumstances, however, for example when the receptacle is arranged with its central longitudinal axis tangential to a circle about the central vertical axis of the tubing hanger (rather than radially of the tubing hanger), it is necessary to design the plug body and mounting with a relatively long portion of the plug body projecting forwardly of the mounting. The weight of the forwardly projecting portion creates a couple which increases friction at the mounting and thus restricts its ability to allow the plug body to move relative to the carriage during correction to connect any misalignment. Another possible cause of restricted movement at the mounting is the presence of sand or other debris, which may create a problem even if the forwardly projecting portion of the plug body is relatively short.

According to a first inventive aspect there is provided a connector assembly comprising first and second connector parts, the first connector part being

mounted by a carriage reciprocatable between a forward position for connecting the connector parts and a retracted position for disconnecting the connector parts, wherein the mounting of the first connector part by the carriage is such as to permit pivoting of the first connector part in response to a force in any lateral direction on the first connector part and acting at a location forward of the mounting.

If there is misalignment of the connector parts when disconnected, as they are brought into engagement the first connector part can align itself with the second connector part. The pivotal mounting of the first connector part enables the correction in alignment to be achieved. Thus any tendency for the first connector part to become jammed during the connection process as a result of misalignment is reduced.

The lateral force may for example be horizontal or vertical, both of these being lateral to the longitudinal axis of the first connector part, or a combination of the two, depending on the direction of misalignment to be corrected. As discussed above, there may be a tendency for the first connector part to tilt downwardly, when disconnected, due to the weight of the portion of the first connector part projecting forwardly of the mounting. In such a situation, since the mounting can permit downward pivoting about a horizontal axis, its functioning will not be impaired by increased friction, as in the known mounting system. The downward tilting can be reversed as the first and second connector parts engage with each other and a correcting lateral (i.e. upward) force is applied by the second connector part to the first connector part.

Preferably, one of the connector parts is a plug body and the other a plug receptacle. In order to help correct misalignment during the forward stroke of the carriage, the plug body may have an externally chamfered nose whilst the plug receptacle may have an internally

chamfered mouth. If there is misalignment, the chamfers allow the nose to engage in the mouth during the carriage forward stroke. It is preferred that the first connector part is the plug body and that the second connector part is the plug receptacle, although the reverse arrangement is possible.

The connection to be made may be electrical (such as low power for gauges or other instrumentation or high power for powering equipment such as a down hole pump) or optical or a mixture of the two. A preferred connector, having first and second connector parts for use in the connector assembly, is described in GB-A-2 192 316.

Another cause of an initial angular misalignment of the first connector part, in addition to the downward tilting mentioned above, may be an eccentric load applied by a cable extending from the rear of the first connector part. In many cases, the problem of an initial angular misalignment is overcome, as the desired final orientation of the first connector part can be achieved by the application of a correcting lateral force by the second connector part as the two are brought into engagement. The pivotal mounting enables this to be achieved. However, in situations where the length of the first connector part projecting forwardly of the mounting is relatively long (as in the case for example of a non-radial entry to a tubing hanger mentioned above), there is a corresponding increased effect of any angular misalignment at the front end of the first connector part, where it first engages with the second connector part during the forward stroke of the carriage. In an extreme case, it may not be possible to achieve connection.

Preferably, therefore, the mounting is such as to centre and align the first connector part along a predetermined axis when the carriage is in the retracted position. Such an arrangement ensures that the first

connector part is in the proper orientation relative to the carriage, despite any forces applied to the first connector part by its own weight or a cable connected to it. There may of course still be misalignment between the first and second connector parts, caused by misalignment of the carriage relative to the second connector part, but this will normally be small and readily correctable during the connection process.

Apart from an angular misalignment relative to the axial direction there may be a lateral offset and therefore preferably the mounting of the first connector part is such as to permit lateral movement of the first connector part relative to the carriage.

In a preferred arrangement the first connector part is resiliently mounted by the carriage. This can be useful in achieving a proper connection between the first and second connector parts. For example, the assembly can be designed such that the first and second connector parts are fully connected and seated against each other slightly before the carriage completes its forward stroke to the forward position, with the additional movement of the carriage being permitted by the resilience of the mounting. Thus the carriage can be arranged to move forward by more than the first connector part, reducing the chance that there will not be a proper connection because of manufacturing errors or because of debris preventing the carriage from completing its forward stroke.

The first connector part may be mounted in a block of resilient material, such as a solid rubber bushing. However, in certain uses of the connector assembly, such as in a wellhead, the resilient material would have to be tolerant of the well completion fluid (generally brine), of high temperatures (typically 145°C or more at certain times), and would preferably not be susceptible to compression set. It is therefore generally preferred to provide resilience by the use of one or more springs

of steel or the like.

Preferably the first connector part has a bearing portion biased against an abutment of the carriage. Such a bearing arrangement should permit pivoting of the first connector part and preferably also will be such as to centre and align the first connector part when disconnected. This can be achieved if the bearing portion has a conical face engaging a conical face of the abutment. One conical face will be "concave", in the form of a cup, and the other will be "convex". The convex conical face will thus be able to "rock" within the concave conical face to provide the desired pivotal movement. Preferably, the convex conical face belongs to the first connector part and the concave conical face to the carriage, but the reverse is possible. By providing adequate lateral clearance between the bearing portion and the abutment, relative lateral movement will also be possible.

Advantageously, the bias of the bearing portion of first connector part against the abutment of the carriage is resilient, thus providing the mounting with its preferred resilience. Although the bearing portion could be biased rearwardly, e.g. by one or more springs, it is preferred that the bearing portion is forwardly biased.

Preferably, the bias is provided by a compression spring coiled round a shaft projecting rearwardly of the bearing portion and biasing the bearing portion forwardly against the abutment. This provides an economical use of space whilst also enabling some longitudinal play allowing the carriage to stroke forward by more than the forward movement required by the first connector part to achieve proper connection.

If the connection involves the mating of a single centrally located pin in a corresponding socket, then it may not be essential to maintain the first and second connector parts rotationally aligned when disconnected.

Preferably, however, there is provided means for preventing rotation of the first connector part relative to the carriage about a longitudinal axis. This may for example take the form of a longitudinally arranged pin engaging in a corresponding hole.

In our known mounting arrangement described above, a cable protrudes from the rear end of the plug body, at an angle to the longitudinal axis and at an off-centre location. This can result in the cable applying a force to the plug body which causes it to be out of alignment with the carriage. In order to minimise such a problem, a preferred embodiment of the present invention comprises a cable extending axially and centrally from a rear end of the first connector part. It may be desired to form the cable to the rear of the first connector part into a coil about a longitudinal axis, in order to accommodate forward and rearward reciprocating movement of the first connector part. In this arrangement, since the deviation of the cable from the central axis first occurs behind the first connector part, it has a reduced potential for eccentric loading on the first connector part than in the known mounting arrangement.

The connector assembly is preferably an underwater or other severe environment connector assembly. It is envisaged that it will be particularly useful as part of a wellhead installation.

A preferred embodiment therefore comprises a wellhead assembly comprising a radially inner member, a radially outer member, and a connector assembly as described above, wherein the carriage and the first connector part of the connector assembly are carried by the radially outer member and the second connector part is carried by the radially inner member.

With such an arrangement, when the carriage is in the retracted position, the connector parts are disconnected and allow relative axial movement of the radially inner and outer members. The radially inner

member may for example be a tubing hanger and the radially outer member a spool body.

In known connector assemblies there may in some circumstances be difficulties in withdrawing the carriage to the retracted position, for example due to a failure of an actuator for the carriage, or seizure of the carriage in its guide, or seizure of the connector parts in their connected condition. If this happens, it may be desired to try and recover one of the two members which carry the respective connector parts of the connector assembly, without recovering the other member. In the example mentioned above of a wellhead assembly, it may be desired to remove the tubing hanger from the spool body to take it to surface for repair or modification. If however the carriage cannot be retracted then the first connector part will normally prevent recovery of one of the members without the other, because it extends between the two when the carriage is in the forward position.

According to a second inventive aspect there is provided a connector assembly comprising first and second connector parts, the first connector part being mounted by a carriage reciprocatable between a forward position for connecting the connector parts and a retracted position for disconnecting the connector parts, wherein the first connector part comprises a weakened portion providing a reduced resistance to shear.

With such an arrangement the first connector part can if necessary be sheared at the weakened portion. Although this will result in the destruction of the first connector part, this may be a justifiable sacrifice if it enables recovery of a member carrying the first or second connector part. Thus, if the carriage and the first connector part are carried by a first member, and the second connector part is carried by a second member, then one of the members may be

recovered even if the carriage cannot be retracted by shearing the first connector part.

The shear load may for example be reduced from an order of 20 tonnes to an order of 6 to 9 tonnes at the weakened portion.

In one embodiment, the weakened portion is located on the first connector part at a region adjacent to a front end of the second connector part when the connector parts are connected (the "front end" of the second connector part meaning the end nearest the carriage). Such an arrangement is useful for example if the second connector part is to be carried by a second member with its front end at the periphery of the second member, so that shear can occur at the periphery. It may also be useful if the second connector part is to be carried by a second member with its front end inwardly (i.e. rearwardly in relation to the second connector part) of the periphery of the second member. Shearing of the first connector part can then occur at the front end of the second connector part, inwardly of the periphery. However, in this latter disposition of the connector assembly, an alternative embodiment comprises the location of the weakened portion on the first connector part at a region rearwardly of a front end of the second connector part when the connector parts are connected (i.e. rearwardly in relation to the first connector part). For example, the weakened portion can be located at the periphery of the second connector part, so that shear can occur at this point.

The weakened part may be in the form of a peripherally extending groove in an outer wall of the first connector part. It may run transverse to the longitudinal axis, or at a non-perpendicular angle to the longitudinal axis, for example to correspond to the profile of the periphery of a second member as viewed in the direction of shear.

One of the connector parts is preferably a plug and

the other a receptacle, with the plug being receivable in the receptacle to make a connection. Preferably, the first connector part is the plug and the second connector part the receptacle, although the reverse arrangement is possible.

It is expected that the connector assembly including a first connector part with a weakened region will be particularly useful as part of a wellhead installation.

A preferred embodiment therefore comprises a wellhead assembly comprising a radially inner member, a radially outer member, and a connector assembly comprising first and second connector parts, the first connector part being mounted by a carriage reciprocatable between a forward position for connecting the connector parts and a retracted position for disconnecting the connector parts, wherein the carriage and the first connector part of the connector assembly are carried by the radially outer member and the second connector part is carried by the radially inner member, and wherein the first connector part comprises a weakened portion providing a reduced resistance to shear.

If it is desired to remove the radially inner member from the radially outer member, this can be achieved even if the carriage cannot be retracted, by shearing the first connector part.

Certain preferred embodiments of the invention will now be described by way of example and with reference to the accompanying drawings in which:

Fig. 1 is a longitudinal sectional view, in a horizontal plane, of a first embodiment of connector assembly in a wellhead installation;

Fig. 2 is a cross-sectional view through an actuator stem of the connector assembly, along the lines II-II of Fig. 1; and

Figs. 3, 4 and 5 are respective partial

longitudinal sectional views (in a vertical plane) of second, third and fourth embodiments respectively of connector assemblies in wellhead installations.

Referring to Figure 1, a connector assembly 1 is installed in a wellhead installation which includes a radially inner member in the form of a tubing hanger 2 and radially outer members comprising a spool body 3 and a bonnet 4. The connector assembly 1 comprises a first connector part in the form of a plug body 5 and a second connector part in the form of a receptacle 6. The plug body 5 has an outer wall 14. It is supported by a carriage 7 which is longitudinally reciprocatable in a guide tube 8. The carriage 7 is shown in its retracted position in which a chamfered front end 9 of the plug body 5 is disposed rearwardly of the tubing hanger 2.

The receptacle 6 of the connector assembly is carried by the tubing hanger with its longitudinal axis tangential to a circle about the central vertical axis of the tubing hanger 2. It is disposed inwardly of the outer periphery of the tubing hanger. It includes an electrical contact pin 10 which at its front end has a contact portion 12 and at its rear is connected to a down hole instrument cable 11. The receptacle 6 has an inner wall 15 terminating at its front end in a chamfered mouth 13. A rear end wall 16 is located at the rear of the receptacle.

The contact pin 10 is arranged to be received in a contact sleeve (not shown) internally of the plug body 5. The internal components of the plug body 5 are not shown as they are known. A typical arrangement of the internal components may be in accordance with the teachings of GB-A-2 192 316. In this known arrangement the contact sleeve is received in an inner chamber containing dielectric oil and having a wall formed of a flexible membrane, the inner chamber being located within an outer chamber also containing dielectric oil and having a wall formed of a flexible membrane. This

latter wall is exposed to pressure outside the plug body. When the plug body is disconnected, a shuttle pin is forwardly spring biased to a position in which it passes through the contact sleeve, through a seal at the front of the inner chamber and through a seal at the front of the outer chamber. During connection, the contact pin 10 pushes the shuttle pin rearwardly so that the pin then passes through the outer and inner chamber seals and its contact portion 12 is received in the contact sleeve.

Other constructions and arrangements for the internal components of the connector parts 5 and 6 are of course possible. In particular, the plug body may be received by the tubing hanger 2 and the receptacle may be mounted by the carriage 7. The plug body may have a single dielectric oil containing chamber, rather than inner and outer chambers as described above. Multipin arrangements could be used in addition to the single pin arrangement shown in Figure 1.

At its rear end the plug body 5 is provided with a compliant mounting. The plug body has a bearing portion in the form of a laterally outwardly extending and forward facing conical face 20, which is "convex" as viewed in Figure 1. A cylindrical portion 21 of the same diameter as the maximum diameter of the conical face 20 is disposed to the rear of the conical face. A location pin 22 projects rearwardly from the cylindrical portion 21 and locates in a slot 23 formed in the carriage 7, in order to prevent rotation of the plug about its longitudinal axis. A cylindrical shaft 24 projects coaxially rearwardly of the cylindrical portion 21 and a barbed cable connector 25 projects coaxially rearwardly of the shaft 24. A cable 26 comprising a rubber tube 27 and a pair of cable wires 28 protrudes axially from the rear of the plug body 5 and then deviates laterally into a coiled form. The cable 26 is retained on the barbed cable connector 25 by a tube

retaining sleeve 29. A part-cylindrical actuator stem 30 is formed at its front end with upper and lower slots 31 engaged by lugs 32 of the carriage 7. The tube retaining sleeve 29 is received in the hollow portion of the stem 30 in a manner which permits it to move in any lateral direction (see Figure 2). The stem 30 extends rearwardly to an actuator mechanism, which can be of any known design. The cable 26 is coiled about the stem 30 so that it can readily accommodate longitudinal movement of the carriage 7.

A compression spring 33 is disposed about the shaft 24 of the plug body 5 and acts between a thrust washer 34 retained by a shoulder 35 of the carriage 7 and a rear face 36 of the cylindrical portion 21. The spring 33 thus urges the plug body forwardly in a resilient manner, such that the conical face 20 engages an abutment of the carriage 7, in the form of a conical face 37 of a cup washer 38. The conical face 37 is "concave" as viewed in Figure 1. The cup washer 38 is retained in the carriage 7 by a locking ring 39. The maximum diameter of the conical face 37 of the cup washer 38 is greater than that of the conical face 20 of the plug body 5, thereby permitting relative pivoting and lateral movement. It will be noted that the interengaging conical faces 20 and 37, under the bias of the spring 33 tend to centre the plug body along the central longitudinal axis of the carriage 7. The force of the spring 33 will be generally sufficient to do this despite the weight of the plug body 5 projecting forwardly of the mounting.

The operation of the connector assembly will now be described. In order to stroke the plug body 5 forwardly, the actuating mechanism (not shown) is operated and the stem 30 urges the carriage 7 and the plug body 5 forwardly. If there is misalignment between the plug body 5 and the receptacle 6 then this will be corrected as the chamfered front end 9 of the plug body

engages in the chamfered mouth 13 of the receptacle 6. The mouth 13 effectively applies an initial lateral force to the front end 9. With further forward movement of the plug body, the engagement between the plug outer wall 14 and the receptacle inner wall 15 brings the respective component parts fully into alignment. The compliant mounting of the plug body on the carriage permits any necessary correction in alignment to take place.

The connector assembly is designed so that the front end 9 of the plug body 5 engages the rear end wall 16 of the receptacle slightly before the carriage 7 completes its forward stroke. The additional forward movement of the carriage 7 relative to the plug 5 is taken up by compression of the spring 33. This arrangement ensures that the connection is completed even if the carriage cannot quite complete its normal stroke, for example due to manufacturing errors or the presence of debris within the carriage guide 8. Also, if the plug body 5 has to move rearwardly relative to the carriage 7 in the course of correcting any misalignment, then it is desirable that the carriage can move forward enough to complete the mating of the plug body 5 in the receptacle 6.

A second embodiment of connector assembly 1 is shown in Figure 3. This shows a section taken in a vertical plane, unlike the section of Figure 1 which is in a horizontal plane. The receptacle 6 is arranged with its central longitudinal axis positioned radially of the tubing hanger, unlike the arrangement shown in Figure 1. This embodiment also differs from the first embodiment in that it shows a multipin connector assembly. An important difference is the presence of a weakened region 40 in the outer wall 14 of the plug body 5. The weakened portion is positioned so as to be located at the periphery of the tubing hanger 2 when the plug body 5 and receptacle 6 are fully mated. Thus, if for any

reason it is not possible to withdraw the plug body from the receptacle, the plug body 5 can be sheared at the weakened portion 40 to enable the tubing hanger 2 to be vertically lifted from the spool body 3.

The weakened portion 40 comprises an annular groove in the outer wall 14. In one example, the wall has a nominal thickness of 0.1595 inches and the groove has a nominal depth of 0.1125 inches, thereby reducing the thickness of the wall at the weakened portion 40 to a nominal value of 0.047 inches. The groove preferably has a "V" shape as viewed in cross-section, enclosing for example an angle of 65°. Such an arrangement, in a steel plug body, can provide a shear strength of the plug body and its components at the weakened portion 40 of about 6 to 9 metric tonnes.

The third and fourth embodiments of Figures 4 and 5 are similar to the first embodiment of Figures 1 and 2, except that the plug body 5 includes weakened portions 40. In the embodiment of Figure 4 the weakened portion is positioned so as to be at the mouth 13 of the receptacle 6 when the connector is fully mated, so as to promote shear in this region if it is necessary to lift the tubing hanger without first being able to withdraw the plug body 5 from the receptacle 6.

In the embodiment of Figure 5, the weakened portion 40 has a curved profile corresponding to that of the outer periphery of the tubing hanger 2, so as to promote shearing in this region if it is necessary to lift the tubing hanger from the spool body without first retracting the plug body 5.

Claims

1. A connector assembly comprising first and second connector parts, the first connector part being mounted by a carriage reciprocatable between a forward position for connecting the connector parts and a retracted position for disconnecting the connector parts, wherein the mounting of the first connector part by the carriage is such as to permit pivoting of the first connector part in response to a force in any lateral direction on the first connector part and acting at a location forward of the mounting.

2. A connector assembly as claimed in claim 1, wherein the mounting is such as to centre and align the first connector part along a predetermined axis when the carriage is in the retracted position.

3. A connector assembly as claimed in claim 1 or 2, wherein the first connector part is resiliently mounted by the carriage.

4. A connector assembly as claimed in claim 1, 2 or 3, wherein the first connector part has a bearing portion biased against an abutment of the carriage.

5. A connector assembly as claimed in claim 4, wherein the bearing portion has a conical face engaging a conical face of the abutment.

6. A connector assembly as claimed in claim 4 or 5, wherein the bias is provided by a compression spring coiled round a shaft projecting rearwardly of the bearing portion and biasing the bearing portion forwardly against the abutment.

7. A connector assembly as claimed in any preceding claim, comprising means for preventing rotation of the first connector part relative to the carriage about a longitudinal axis.

8. A connector assembly as claimed in any preceding claim, comprising a cable extending axially and centrally from a rear end of the first connector part.

9. A wellhead assembly comprising a radially inner member, a radially outer member, and a connector assembly as claimed in any preceding claim, wherein the carriage and the first connector part of the connector assembly are carried by the radially outer member and the second connector part is carried by the radially inner member.

10. A connector assembly comprising first and second connector parts, the first connector part being mounted by a carriage reciprocatable between a forward position for connecting the connector parts and a retracted position for disconnecting the connector parts, wherein the first connector part comprises a weakened portion providing a reduced resistance to shear.

11. A connector assembly as claimed in claim 10, wherein the weakened portion is located on the first connector part at a region adjacent to a front end of the second connector part when the connector parts are connected.

12. A connector assembly as claimed in claim 10, wherein the weakened portion is located on the first connector part at a region rearwardly of a front end of the second connector part when the connector parts are connected.

13. A wellhead assembly comprising a radially inner member, a radially outer member, and a connector assembly as claimed in claim 10, 11 or 12, wherein the carriage and the first connector part of the connector assembly are carried by the radially outer member and the second connector part is carried by the radially inner member.

14. A connector assembly substantially as hereinbefore described with reference to Figures 1 and 2 or Figure 3 or Figure 4 or Figure 5 of the accompanying drawings.

15. A wellhead assembly substantially as hereinbefore described with reference to Figures 1 and 2 or Figure 3 or Figure 4 or Figure 5 of the accompanying drawings.

Patent Office

19

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Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): H2E(ECD)

Int Cl (Ed.6): H01R H02G

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB 2 192 316 A	(Tronic)	
A	US 5 558 532	(Cooper Cameron)	
A	US 4 942 356	(Snap-on Tools)	

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